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Swiftsure and Amphitrite Banks Juvenile Salmon Survey, September 25-29, October 9-13, November 16-18 and November 23-25, 1987

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SWIFTSURE AND AMPHITRITE BANKS JUVENILE SALMON SURVEY, SEPTEMBER 25-29, OCTOBER 9-13, NOVEMBER 16-18 AND NOVEMBER 23-25, 1987

by

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ABSTRACT

Olsen, N. H., J. F. T. Morris, and M. C. Healey. 1988. Swiftsure and Amphitrite banks juvenile salmon survey, September 25-29, October 9-13, November 16-18 and November 23-25, 1987. Can. Tech. Rep. Fish. Aquat. Sci. 1615: 25 p.

Aggregations of juvenile chinook (Oncorhynchus tshawytscha) and coho (O. kisutch) salmon are known to exist over Swiftsure and other banks, which lie on the continental shelf off southwest Vancouver Island. These aggregations are hypothesized to form in response to eddies caused by tidal current rectification.

In the spring and fall, respectively, the summer and winter circulation over the continental shelf undergo a transition phase during which eddying and other stable components of shelf circulation break down. We hypothesize that these events cause the dispersal and redistribution of juvenile salmon aggregations.

Employing commercial trolling methods, we conducted exploratory surveys on Swiftsure and Amphitrite Banks in September, October, and November of 1987 to obtain data on juvenile abundance, distribution, and size and species compositions before and during the fall transition. This report summarizes the information obtained.

RÉSUMÉ

Olsen, N. H., J. F. T. Morris, and M. C. Healey. 1988. Swiftsure and Amphitrite banks juvenile salmon survey, September 25-29, October 9-13, November 16-18 and November 23-25, 1987. Can. Tech. Rep. Fish. Aquat. Sci. 1615: 25 p.

On sait qu'il existe des concentrations de jeunes saumons quinnats (Oncorhynchus tshawytscha) et cohos (O. kisutch) au-dessus du banc Swiftsure et d'autres bancs de la plate-forme continentale situés au large de la côte sud-ouest de l'île Vancouver. On émet l'hypothèse que ces concentrations se forment suite à des tourbillons provoqués par un redressement des courants de marée.

Au printemps et à l'automne, respectivement, la circulation estivale et hivernale au-dessus de la plate-forme continentale passe par une phase de transition au cours de laquelle les tourbillons et d'autres constituants stables de la circulation sur la plate-forme s'atténuent. Les auteurs formulent l'hypothèse que ces phénomènes provoquent la dispersion et la redistribution des concentrations de jeunes saumons.

En utilisant des méthodes commerciales de pêche à la traîne, les auteurs ont réalisé des relevés d'exploration sur les bancs Swiftsure et Amphitrite pendant les mois de septembre, octobre et novembre 1987 afin d'obtenir des données sur l'abondance des jeunes, sur leur répartition, ainsi que sur la composition des espèces et des tailles avant et pendant la phase de transition automnale. Le présent rapport fait le résumé des renseignements obtenus.

INTRODUCTION

Juvenile chinook (Oncorhynchus tshawytscha) and coho (O. kisutch) salmon are known to aggregate on Swiftsure and other banks which lie on the continental shelf off southwestern Vancouver Island. Although the reasons for this aggregating behavior are not known, Freeland (1987) hypothesized that eddies form over the banks as a result of rectification of tidal currents, thus providing energetically favourable areas in which juvenile salmon can maintain geographic position. Alternatively, localized, topographic upwelling may occur, creating rich feeding grounds to which the young salmon congregate.

Although oceanographic conditions off the west coast of Vancouver Island are relatively stable throughout the summer and winter, the spring and fall are periods of transition during which the winds, and consequently the ocean currents, undergo a transition (Thomson et al. 1988). In the spring, the winds change direction from predominantly southeast to predominantly northwest and vice versa in the fall. At these times we hypothesize that the breakdown of eddies and other stable components of shelf circulation result in the dispersal and redistribution of juvenile chinook and coho salmon.

As a preliminary step to testing these various hypotheses, we conducted exploratory surveys employing commercial trolling methods during the fall transition on Swiftsure, Amphitrite and other banks off the southwest coast of Vancouver Island. The objectives of these cruises were to obtain preliminary data on the abundance, distribution, size, and species composition of juvenile aggregations before and during the fall transition and to assess the adequacy of trolling as a sampling technique. This report gives the information on the fishing locations, and summarizes catch rates, and species and size compositions of juvenile salmon obtained from cruises in September, October, and November, 1987.

In addition, surveys of sea bird activity in the area and sampling of sea birds for stomach analysis were conducted in September and October, just prior to the sampling of juvenile salmon aggregations. The purpose of this sampling was to determine the importance of marine birds as predators of juvenile salmon. The results of these surveys will be reported elsewhere.

The present study is part of the Marine Survival of Salmon (MASS) program, a multidisciplinary effort involving the biological, and physical and chemical science branches of Fisheries and Oceans. The main objective of the MASS program is to determine the interrelationships between biophysical events in the ocean and the dispersal and survival of salmon.

METHODS

VESSEL AND GEAR

In the fall of 1987, the Department of Fisheries and Oceans chartered a 42 foot commercial ice troller, the M.V. ISLAND VENTURE, to conduct a juvenile salmon survey on Swiftsure and Amphitrite Banks and adjacent areas.

During this survey we sampled juvenile salmon having fork lengths less than or equal to 40 cm captured on commercial trolling gear consisting primarily of hoochies with flashers and, to a lesser extent, Tom Mack spoons. On the October and November cruises we employed two bow lines, two main lines, and two pig lines carrying four to six lures each, while on the September cruise we used two bow lines and two main lines also carrying four to six lures each (Table 1).

SAMPLING STRATEGY

We conducted sampling of juvenile salmon on the following days: September 25-29, October 9-13, November 16-18, and November 23-25, 1987. Originally we scheduled each cruise to consist of five consecutive days of fishing with sampling done on Amphitrite bank on the first and last days, Swiftsure bank on the second and third days, and various banks which lie between Amphitrite and Swiftsure, on the fourth day. We followed this schedule on the September and October cruises but poor weather forced us to extend the November cruise to include two sessions of three days each and to modify the sequence of areas sampled (Table 1).

TREATMENT OF SAMPLES

We recorded the species and fork length of each juvenile captured, as well as the location, time, and depth of capture. We labelled all the juveniles kept with an identifying tag which we inserted into the body cavity via a small incision made beginning at, and proceeding approximately 4 cm anterior to, the anus. We then preserved each sample in 10 % formalin in sealable plastic buckets.

On days when the juvenile catch rate was very high (over 0.8 fish per line per hour), we preserved a subset of the total catch of the day. This usually meant taking all juveniles which had been seriously injured, those with clipped adipose fins, and, to supplement these, an additional number that were arbitrarily chosen.

When releasing juveniles, we first measured and recorded them and then, because the hooks were unbarbed, shook them off the lure into the water by means of a gaff. We similarly released all adult salmon and other incidental catch such as rockfish, after recording depth of capture and, if a salmon, the species.

ADDITIONAL DUTIES

In addition to sampling juvenile salmon, we made weather observations and took sea surface temperature readings at various locations. We also deployed expendable bathythermographs at various times throughout the September and November cruises but, due to equipment failure, not on the October cruise.

Personnel from the Canadian Wildlife Service conducted sea bird observations and took samples of sea birds for stomach analysis during the three days prior to each of the September and October cruises on the dates of September 22-24 and October 6-8. They also conducted their surveys on board the M.V. ISLAND VENTURE.

ADJUSTMENT OF JUVENILE SALMON CATCH RATES

On days when a large number of adult salmon and other species were caught, the juvenile catch rate may be misleading because these fish may compete with the juveniles for lures. Therefore, we adjusted the juvenile catch rates by a calculation that accounted for estimated reductions in fishing effort caused by hooked adult salmon and other species occupying lures that were deployed to capture juveniles. The steps of the calculation are as follows:

1) We estimated the average time in minutes the lures were in the water, actively fishing per hour of trolling in the following manner: On days when the combine catch rate was less than three, we fished each line on an approximate 30 minute cycle, in which we trolled for 20 minutes and checked the line for 10 minutes. Checking the line meant winding in the line, unclipping the lures from the line as it was brought in, unhooking and recording the catch, then re-attaching the lures as the line was re-deployed. We estimated that while the line was being checked the average time all the lures were fishing was 5 minutes. Therefore, the lures on each line would have been available to catch juveniles for 25 minutes during a 30 minute cycle, or 50 minutes per hour. On days when the combine catch was three or more, we fished each line on an approximate 20 minute cycle, in which we trolled for 10 minutes and checked the line for 10 minutes. In this case, we estimated that the lures on each line were fishing for 45 minutes per hour of trolling.

2) We calculated the maximum fishing effort in terms of lure minutes per hour by multiplying the number of lures deployed by the estimated time in minutes the lures were fishing per hour of trolling.

3) We calculated the reduction in fishing effort by multiplying the number of adult salmon and other species caught per hour by the estimated time these fish would be occupying lures during a 20 or 30 minute fishing cycle, which was 7.5 and 13.5 minutes, respectively.

4) We calculated the actual fishing effort by subtracting the reduction in fishing effort from the maximum fishing effort.

5) We calculated the adjusted juvenile catch rate by multiplying the juvenile catch rate by the ratio of the maximum fishing effort to the actual fishing effort.

RESULTS AND COMMENTS

ASSESSING THE SAMPLING METHOD

In sampling Swiftsure and Amphitrite banks for juvenile salmon, we benefited in several ways by using commercial trolling methods. Most importantly, trolling provided a means of continuously sampling a large area at a constant effort. Therefore, we feel that the catch rates obtained give a good indication of fish density. Furthermore, because we placed lures at regular intervals along the lines, we were able to note the depth at which each juvenile was captured and were able to compare the depth distributions of different species. Finally, had we chosen, we could have varied the magnitude of the effort by pulling in some of the lines or removing some of the lures. This gave us the option of varying the magnitude of the effort to suit the fish densities encountered.

Of the disadvantages we encountered using commercial trolling as a sampling method, the greatest was the serious injury which was inflicted on a large number of fish as a result of being hooked. This was particularly evident on the September cruise when a number of adult salmon were needlessly killed. In addition, the large incidental catch of adults in September may have influenced the juvenile catch rate through competition for lures. Throughout the survey, we had to rely on assumption that the juveniles would take our lures. Failing this, it is possible that we passed through areas in which juveniles were present but not feeding or feeding on organisms other than those which our lures were intended to mimic and thus we would have recorded no juvenile catch.

JUVENILE CATCH RATES

The juvenile catch rate, measured as numbers of juveniles caught per line fished per hour, was greater on Swiftsure Bank than on Amphitrite Bank on each of the three cruises. On Swiftsure Bank, the juvenile catch rate ranged from 0.976 in September, to 2.196 in October, and to a low of 0.844 in November (Table 2).

At first, we thought that the September juvenile catch rate on Swiftsure Bank may be misleading since a large number of adults, which may have competed with the juveniles for lures, were also caught. However, the adjusted juvenile catch rate, that is derived from an estimate of the reduction in fishing effort caused by the estimated length of time and proportion of lures that were occupied by adult salmon and other species while trolling, was only slightly higher than the juvenile catch rate.

On Amphitrite Bank, the juvenile catch rates indicate an increasing juvenile density from September to November. The juvenile catch rate in this period ranged from 0.197 in September to 0.586 in November.

Juvenile catch rates were also lower on 6 and 12 Mile Banks than on Swiftsure Bank in September and October. However, the juvenile catch rate on the eastern end of the 6 Mile Bank, at 2.500, was three times higher than on Swiftsure Bank in November.

SPECIES COMPOSITION

On Swiftsure Bank, the juvenile catch was dominated by coho on all cruises and ranged from 94.0 and 97.4 percent of the catch in September and October, respectively, to a low of 79.2 percent in November. Chinook juveniles composed the balance of the juvenile catch in September and October. In November, chinook juveniles were second in abundance at 17.0 percent. Pink (O. gorbuscha) juveniles appeared on Swiftsure for the first time in November and they accounted for 3.8 percent of the catch (Table 2).

On Amphitrite Bank, coho dominated the juvenile catch in September and October at 93.3 and 74.2 percent of the catch, respectively. Chinook composed the remainder of the juvenile catch. In November, however, coho composed only 28.2 percent of the juvenile catch while chinooks were the most abundant at 43.6 percent. Pinks were as abundant as coho at 28.2 percent.

On 6 and 12 Mile Banks in September, coho composed 100.0% of the juvenile catch. The catch composition percentages on 6 and 12 Mile Bank in October, and on the eastern end on 6 Mile Bank and the entrance to Barkley Sound in November are not very meaningful because we caught less than 20 juveniles there.

SIZE DISTRIBUTIONS

The average fork length of coho juveniles remained relatively constant from September to October, at 32.8 and 32.7 cm, respectively. In November, the average increased to 33.9 cm (Table 3a).

Chinook juveniles also maintained a relatively constant average fork length in September and October (32.0 and 31.6 cm, respectively) but this average decreased in November to 28.1 cm (Table 3b).

Pink juveniles, caught only in November, had the smallest average fork length of any of the three species of juveniles caught, at 22.8 cm (Table 3c).

DEPTH DISTRIBUTIONS

Coho juveniles occurred over the entire range of depths fished, from 2 to 64 meters, but they were more abundant at depths less than 42 meters. In September, October, and November, we caught 86.0, 100.0, and 98.5%, respectively, of the coho juveniles at less than 42 meters. In October and November, we caught coho juveniles at an average depth of 21.7 and 20.8 meters, respectively. In September, the average depth of capture was 29.9 but this figure is misleading because we did not deploy any lures between 2 and 10 meters on this cruise. In October, coho juveniles were particularly abundant between 10 and 26 meters, as indicated by the relatively higher catch rates at these depths (Table 4a).

Chinook juveniles occurred at depths ranging from 10 to 64 meters, but we caught them at deeper average depths than coho juveniles. In September, October, and November, the average depth of capture was 39.2, 34.4, and 33.5 meters, respectively (Table 4b).

Pink juveniles were widely distributed over the range of 2 to 42 meters and the average depth of capture was 20 meters (Table 4c).

AKNOWLEDGMENTS

We would like to thank Vince Fantillo, skipper of the M.V. ISLAND VENTURE, for his valuable and friendly assistance during the surveys on Swiftsure and Amphitrite Banks and for sharing his knowledge and expertise of commercial trolling in and around these areas.

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TABLE 1. THE AREAS SAMPLED, THE TOTAL TROLLING TIME, AND THE DEPTH, IN METERS, OF LINES DEPLOYED DURING EACH CRUISE.

DATE	AREA SAMPLED	BOW LINES	MAIN LINES	PIG LINES	NUMBER OF LURES	TROLLING TIME (HOURS)
25/09/87	AMPHITRITE BANK	44	44	NOT USED	18	8.66
26/09/87	SWIFTSURE BANK	40	60	NOT USED	22	11.00
27/09/87	SWIFTSURE BANK	40	60	NOT USED	22	10.25
28/09/87	6 AND 12 MILE BANK	44	60	NOT USED	22	10.92
29/09/87	AMPHITRITE BANK	48	64	NOT USED	22	10.33
09/10/87	AMPHITRITE BANK	40	44	40	32	7.83
10/10/87	SWIFTSURE BANK	40	44	40	32	8.00
11/10/87	SWIFTSURE BANK	40	44	40	32	9.83
12/10/87	6 AND 12 MILE BANK	40	44	40	32	6.33
13/11/87	AMPHITRITE BANK	40	44	40	32	8.92
16/11/87	AMPHITRITE BANK	40	44	40	32	7.08
17/11/87	6 MILE BANK	40	44	40	32	0.80
18/11/87	PACHENA	40	44	40	32	3.72
23/11/87	AMPHITRITE BANK	40	44	40	32	4.00
24/11/87	MOUTH OF BARKLEY SOUND	40	44	40	32	4.25
25/11/87	SWIFTSURE BANK	40	44	40	32	6.75

TABLE 2. THE TOTAL JUVENILE CATCH, THE % COMPOSITION BY SPECIES OF THE JUVENILE CATCH, THE CATCH RATES OF JUVENILE AND ADULT SALMON AND BOTH ROCKFISH AND BOTTOM FISH (OTHERS), AND THE COMBINED CATCH RATE.

SEPTEMBER:

LOCATION AND DATE	TOTAL JUVENILE CATCH	NUMBER JUVENILES BY SPECIES COHO	CHINOOK	PINK	% JUVENILES BY SPECIES COHO	CHINOOK	PINK	JUVENILE/ LINE/HOUR	ADJUSTED JUVENILE/ LINE/HOUR	ADULT/ LINE/HOUR	OTHER/ LINE/HOUR	COMBINED/ LINE/HOUR
AMPHITRITE												
25\09\87	5	5	0	0	100.0	0.0	0.0	0.144	0.148	0.490	-	0.635
29\09\87	10	9	1	0	90.0	10.0	0.0	0.242	0.245	0.096	-	0.339
TOTAL	15	14	1	0	93.3	6.7	0.0	0.197	0.200	0.276	-	0.474
SWIFTSURE												
26\09\87	36	34	2	0	94.4	5.6	0.0	0.818	0.949	4.545	-	5.364
27\09\87	47	44	3	0	93.6	6.4	0.0	1.146	1.222	2.049	-	3.195
TOTAL	83	78	5	0	94.0	6.0	0.0	0.976	1.086	3.341	-	4.318
6 AND 12 MILE												
28\09\87	20	20	0	0	100.0	0.0	0.0	0.458	0.484	1.786	-	2.244

OCTOBER:

LOCATION AND DATE	TOTAL CATCH	NUMBER CAUGHT BY SPECIES COHO	CHINOOK	PINK	% OF TOTAL CATCH BY SPECIES COHO	CHINOOK	PINK	JUVENILE/ LINE/HOUR	ADJUSTED JUVENILE/ LINE/HOUR	ADULT/ LINE/HOUR	OTHER/ LINE/HOUR	COMBINED/ LINE/HOUR
AMPHITRITE												
09\10\87	25	20	5	0	80.0	20.0	0.0	0.532	0.540	0.298	0.000	0.830
13\10\87	6	3	3	0	50.0	50.0	0.0	0.112	0.114	0.280	0.037	0.430
TOTAL	31	23	8	0	74.2	25.8	0.0	0.308	0.313	0.289	0.020	0.617
SWIFTSURE												
10\10\87	107	105	2	0	98.1	1.9	0.0	2.229	2.350	1.396	0.271	3.896
11\10\87	128	124	4	0	96.9	3.1	0.0	2.169	2.241	0.814	0.237	3.220
TOTAL	235	229	6	0	97.4	2.6	0.0	2.196	2.254	1.075	0.252	3.523
6 AND 12 MILE												
12\10\87	6	4	2	0	66.7	33.3	0.0	0.184	0.186	0.184	0.026	0.368

TABLE 2 (CONT'D)

NOVEMBER:

LOCATION AND DATE	TOTAL CATCH	NUMBER CAUGHT BY SPECIES COHO	CHINOOK	PINK	% OF TOTAL CATCH BY SPECIES COHO	CHINOOK	PINK	JUVENILE/ LINE/HOUR	ADJUSTED JUVENILE/ LINE/HOUR	ADULT/ LINE/HOUR	OTHER/ LINE/HOUR	COMBINED/ LINE/HOUR
AMPHITRITE												
16\11\87	26	8	8	10	30.8	30.8	38.4	0.612	0.615	0.043	0.071	0.729
23\11\87	13	3	9	1	23.1	69.2	7.7	0.542	0.546	0.000	0.167	0.708
TOTAL	39	11	17	11	28.2	43.6	28.2	0.586	0.590	0.030	0.105	0.722
SWIFTSURE												
25\11\87	33	26	5	2	78.8	15.1	6.1	0.815	0.828	0.074	0.247	1.136
18\11\87	20	16	4	0	80.0	20.0	0.0	0.897	0.918	0.000	0.448	1.345
TOTAL	53	42	9	2	79.2	17.0	3.8	0.844	0.860	0.048	0.318	1.210
6 MILE												
17\11\87	12	11	0	1	91.7	0.0	8.3	2.500	2.582	0.208	0.417	3.125
BARKLEY SOUND												
24\11\87	9	4	5	0	44.4	55.6	0.0	0.353	0.354	0.000	0.039	0.392

Table 3a. Size composition of juvenile coho salmon.

FORK LENGTH (CM)	SEPTEMBER						OCTOBER						NOVEMBER						
	25	26	27	28	29	(TOTAL)	9	10	11	12	13	(TOTAL)	16	17	18	23	24	25	(TOTAL)
<20.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20.0-21.9	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
22.0-23.9	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	1
24.0-25.9	0	1	0	0	0	1	0	3	2	0	0	5	0	0	0	0	0	0	0
26.0-27.9	1	2	2	0	0	5	0	0	0	0	0	0	0	0	1	0	0	0	1
28.0-29.9	0	0	5	1	1	7	4	5	5	0	0	14	1	0	0	0	1	1	3
30.0-31.9	2	7	6	1	2	18	9	17	18	2	0	46	1	0	0	1	0	0	2
32.0-33.9	3	4	7	6	3	23	5	29	35	2	0	71	0	1	7	0	2	3	13
34.0-35.9	0	11	15	7	1	34	1	29	29	0	3	62	1	2	1	0	1	9	14
36.0-37.9	1	6	6	3	1	17	1	13	22	0	0	36	3	3	1	1	0	7	15
38.0-39.9	0	3	3	2	1	9	0	7	12	0	0	19	2	4	5	0	0	3	14
n	7	34	44	20	9	(114)	20	103	125	4	3	(255)	8	11	15	2	4	23	(73)
mean	31.4	32.9	32.6	33.6	32.4	(32.8)	30.6	32.7	33.0	31.0	34.0	(32.7)	35.4	34.7	34.0	33.0	31.5	34.6	(33.9)
s.d.	3.0	3.4	3.1	2.5	3.1	(3.1)	2.1	2.9	3.2	1.2	0.0	(3.1)	3.7	4.7	3.6	4.2	2.5	2.3	(3.2)

Table 3b. Size composition of juvenile chinook salmon.

FORK LENGTH (CM)	SEPTEMBER						OCTOBER						NOVEMBER						
	25	26	27	28	29	(TOTAL)	9	10	11	12	13	(TOTAL)	16	17	18	23	24	25	(TOTAL)
<20.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20.0-21.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
22.0-23.9	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	2	0	5
24.0-25.9	0	1	0	0	0	1	0	0	0	0	0	0	3	0	0	0	2	0	5
26.0-27.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	3
28.0-29.9	0	0	0	0	0	0	0	0	1	0	1	2	0	0	0	3	0	0	3
30.0-31.9	0	0	1	0	0	1	0	0	0	2	0	2	1	0	0	0	0	1	2
32.0-33.9	0	0	1	0	0	1	3	0	1	0	0	4	0	0	1	0	0	1	2
34.0-35.9	0	0	0	0	0	0	2	0	0	0	1	3	1	0	0	0	0	2	3
36.0-37.9	0	1	0	0	0	1	0	0	1	0	0	1	0	0	1	1	0	0	2
38.0-39.9	0	0	0	0	1	1	0	0	1	0	0	1	1	0	0	1	0	0	2
n	0	2	2	0	1	(5)	5	0	4	2	3	(14)	7	0	4	8	5	4	(28)
mean	0.0	30.0	31.0	0.0	38.0	(32.0)	32.8	0.0	33.5	30.0	28.0	(31.6)	28.0	0.0	29.0	29.0	22.4	32.5	(28.1)
s.d.	0.0	8.5	1.4	0.0	0.0	(5.5)	1.1	0.0	4.4	0.0	6.0	(3.9)	6.1	0.0	6.2	5.4	1.7	1.9	(5.5)

Table 3c. Size composition of juvenile pink salmon.

FORK LENGTH (CM)	NOVEMBER						
	16	17	18	23	24	25	(TOTAL)
<20.0	0	0	0	0	0	0	0
20.0-21.9	3	0	0	0	0	0	3
22.0-23.9	2	0	0	0	0	0	2
24.0-25.9	4	1	0	1	0	2	8
>26.0	0	0	0	0	0	0	0
n	9	1	0	1	0	2	(13)
mean	22.2	24.0	0.0	24.0	0.0	24.0	(22.8)
s.d.	1.9	0.0	0.0	0.0	0.0	0.0	(1.7)

Table 4a. The frequency of depths of capture and the catch rate per depth of juvenile coho salmon.

DEPTH	SEPTEMBER						
(METERS)	25	26	27	28	29	TOTAL	FISH/LINE/HOUR
10-18	1	1	12	2	2	18	0.088
18-26	1	1	10	8	3	23	0.112
26-34	4	6	8	2	3	23	0.112
34-42	1	6	8	5	1	21	0.103
42-50	-	7	1	0	0	8	0.078
50-58	-	3	0	0	0	3	0.035
58-64	-	1	0	2	0	3	0.035
n	7	25	39	19	9	99	
mean	27.7	39.6	25.1	30.3	24.6	29.9	
s.d.	7.6	11.0	9.6	13.7	8.0	12.0	

DEPTH	OCTOBER						
(METERS)	9	10	11	12	13	TOTAL	FISH/LINE/HOUR
2-10	2	12	7	0	0	21	0.086
10-18	5	29	33	1	0	68	0.277
18-26	12	29	36	1	2	80	0.326
26-34	0	13	30	2	1	46	0.187
34-42	0	13	16	0	0	29	0.118
42-46	0	0	0	0	0	0	0.000
n	19	97	122	4	3	245	
mean	18.2	20.6	23.0	24.0	24.6	21.7	
s.d.	5.6	9.2	7.6	7.6	4.6	9.1	

DEPTH	NOVEMBER							
(METERS)	16	17	18	23	24	25	TOTAL	FISH/LINE/HOUR
2-10	0	2	2	0	0	2	6	0.038
10-18	6	5	7	1	0	9	28	0.176
18-26	1	2	4	1	1	7	16	0.100
26-34	1	0	1	1	1	3	7	0.044
34-42	0	2	2	0	1	5	10	0.063
42-46	0	0	0	0	1	0	1	0.019
n	8	11	19	3	4	26	68	
mean	17.0	18.4	20.0	22.0	33.5	22.0	20.8	
s.d.	5.9	10.9	8.8	8.0	9.6	10.1	10.0	

Table 4b. The frequencies of depths of capture of and the catch rate per depth of juvenile chinook salmon.

DEPTH	SEPTEMBER						
(METERS)	25	26	27	28	29	TOTAL	FISH/LINE/HOUR
10-18	0	0	1	0	0	1	0.005
18-26	0	0	0	0	1	1	0.005
26-34	0	0	0	0	0	0	0.000
34-42	0	0	1	0	0	1	0.005
42-50	-	0	1	0	0	1	0.012
50-58	-	1	0	0	0	1	0.012
58-64	-	1	0	0	0	1	0.012
n	0	2	3	0	1	6	
mean	0.0	57.5	32.7	0.0	22.0	39.2	
s.d.	0.0	4.9	16.6	0.0	0.0	18.3	

DEPTH	OCTOBER						
(METERS)	9	10	11	12	13	TOTAL	FISH/LINE/HOUR
2-10	0	0	0	0	0	0	0.000
10-18	0	0	0	0	0	0	0.000
18-26	1	0	0	0	0	1	0.004
26-34	2	0	1	1	1	5	0.020
34-42	2	2	1	1	1	7	0.029
42-46	0	0	0	0	1	1	0.012
n	5	2	2	2	3	14	
mean	31.6	38.0	34.0	34.0	37.3	34.4	
s.d.	6.7	0.0	5.7	5.7	7.0	5.8	

DEPTH	NOVEMBER							
(METERS)	16	17	18	23	24	25	TOTAL	FISH/LINE/HOUR
2-10	0	0	0	0	0	0	0	0.000
10-18	1	0	0	0	0	0	1	0.006
18-26	3	0	0	1	1	0	5	0.031
26-34	1	0	1	2	1	1	6	0.038
34-42	2	0	3	5	3	2	15	0.094
42-46	1	0	0	0	0	2	3	0.056
n	8	0	4	8	5	5	30	
mean	28.8	0.0	36.0	34.0	33.2	38.8	33.5	
s.d.	10.4	0.0	4.0	6.0	7.2	5.8	7.8	

Table 4c. The frequencies of depths of capture and the catch rate per depth of juvenile pink salmon.

DEPTH	NOVEMBER							
(METERS)	16	17	18	23	24	25	TOTAL	FISH/LINE/HOUR
2-10	3	0	0	0	0	0	3	0.019
10-18	3	0	0	1	0	0	4	0.025
18-26	1	0	0	0	0	0	1	0.019
26-34	2	1	0	0	0	1	4	0.025
34-42	1	0	0	0	0	1	2	0.013
42-46	0	0	0	0	0	0	0	0.000
n	10	1	0	1	0	2	14	
mean	15.0	30.0	0.0	14.0	0.0	34.0	20.0	
s.d.	11.8	0.0	0.0	0.0	0.0	5.7	11.7	

Table 5. Bathythermographs.

NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
DATE	26/09/87	26/09/87	27/09/87	27/09/87	27/09/87	28/09/87	28/09/87	29/09/87	29/09/87	18/11/87	25/11/87	25/11/87
LORAN	28908	28943	28962.0	28960.9	29035	29034	29055	29155.6	29129.0	28988.8	28966.4	28932.9
	41820	41839	41837.5	41773.8	41765	41738	41641	41632.0	41622.9	41794.4	41799.4	41830.0
DEPTH (M)	88	62	50	112	62	108	66	54	76	70	76	76
TIME	14:50	19:00	8:30	12:00	19:55	8:40	15:00	10:30	15:30	12:45	11:15	14:45

DEPTH	TEMPERATURE (DEGREES CELSIUS)											
(METERS)	1	2	3	4	5	6	7	8	9	10	11	12
0	12.5	10.9	10.5	12.7	11.0	11.0	11.9	11.6	13.0	10.7	10.9	11.0
10	9.7	10.2	10.0	12.3	10.8	11.0	11.0	11.5	9.0	10.7	10.9	10.9
20	7.0	9.5	9.0	11.0	10.0	9.5	9.5	10.5	8.3	10.7	10.8	10.8
30	4.5	8.1	8.5	6.8	9.0	7.1	6.8	9.0	7.3	10.7	9.7	10.7
40	3.7	7.5	7.2	5.0	8.3	6.0	5.5	7.5	6.5	10.5	8.0	9.5
50	2.7	6.6		3.3	7.0	5.0	4.5	7.3	6.2	7.2	7.4	8.6
60	2.5	5.8		2.7		4.7	4.0		6.1	6.2	6.3	8.0
70	2.0			1.9		4.6			5.0	5.8	5.0	7.5
80				1.7		4.3						
90				1.6		2.8						
100				1.5		2.7						

Table 6. Sea surface temperatures.

DATE	TIME	TEMPERATURE (DEGREES CELSIUS)	AREA
25/09/87	18:15	11.8	AMPHITRITE
27/09/87	14:50	12.4	SWIFTSURE
28/09/87	7:51	10.4	6 AND 12 MILE
29/09/87	8:00	11.8	AMPHITRITE
09/10/87	11:30	12.9	"
	14:00	13.5	"
	16:25	13.4	"
	18:20	10.6	"
10/10/87	9:30	12.4	SWIFTSURE
11/10/87	8:40	9.7	"
	10:00	9.7	"
	12:00	13.0	"
	14:50	13.1	"
	17:15	9.6	"
12/10/87	12:10	12.4	6 AND 12 MILE
13/10/87	8:45	11.2	AMPHITRITE
	12:00	10.6	"
	13:30	11.5	"
16/11/87	10:53	9.7	"
	12:20	9.8	"
	15:35	10.6	"
18/11/87	9:00	10.9	PACHENA
23/11/87	8:00	10.1	AMPHITRITE
	8:50	10.6	"
24/11/87	8:15	10.3	MOUTH OF BARKLEY SOUND
	9:15	10.3	"
25/11/87	9:00	10.8	SWIFTSURE
	9:50	10.9	"
	11:50	10.6	"
	13:15	10.9	"

Table 7. Weather observations.

DATE	TIME	WEATHER	SEA CONDITIONS	WIND
25/09/87	10:30	OVERCAST	CALM	NONE
	17:30	CLEAR	CALM	NONE
26/09/87	8:30	CLEAR	4 FT. SWELL, 6 IN. WAVES, WHITECAPS	12 - 18 KMH
	13:45	CLEAR	SWELL DOWN, NO WHITECAPS	7 - 11 KMH
27/09/87	8:30	FEW CLOUDS	LIGHT SWELL, NO WAVES	NONE
	?	CLEAR	MODERATE SWELL	2 - 6 KMH
28/09/87	7:51	FEW CLOUDS	3 - 4 FT. SWELL, NO WAVES	NONE
	15:00	CLEAR	2 FT. SWELL, NO WAVES	NONE
29/09/87	8:00	CLEAR	1 FT. SWELL, NO WAVES	NONE
	15:30	CLEAR	UNAVAILABLE	7 - 11 KMH
09/10/87	10:40	CLEAR	NO SWELL, RIPPLED	7 - 11 KMH
	18:00	UNAVAILABLE	NO SWELL, 6 IN. WAVES	7 - 11 KMH
10/10/87	9:30	CLEAR	4 FT. SWELL, 2 FT. WAVES, WHITECAPS	EASTERLY, 19 - 29 KMH
	15:00	CLEAR	FEW WHITECAPS	WIND DOWN
11/10/87	8:40	CLEAR	LIGHT SWELL, FEW WHITECAPS	12 - 18 KMH
	16:15	CLEAR	NO WHITECAPS	7 - 11 KMH
12/10/87	8:40	PARTLY CLOUDY	10 FT. SWELL, NO WHITECAPS	7 - 11 KMH
13/10/87	8:45	HAZY	3 FT. SWELL, RIPPLED	EASTERLY, 2 - 6 KMH
	12:15	HAZY	3 FT. SWELL, NO RIPPLES	< 2 KMH
16/11/87	9:15	CLEAR	5 FT. SWELL, RIPPLED, FEW WHITECAPS	EASTERLY, 12 - 18 KMH
17/11/87	9:53	UNAVAILABLE	WHITECAPS	EASTERLY, 19 - 29 KMH
18/11/87	9:00	OVERCAST	WHITECAPS	EASTERLY, 19 - 29 KMH
23/11/87	7:45	OVERCAST, RAIN	5 FT. SWELL, NO WHITECAPS	SOUTHEASTERLY, 7 - 11 KMH
24/11/87	8:15	OVERCAST	10 FT. SWELL, FEW WHITECAPS	NORTHEASTERLY, 12 - 18 KMH
	9:15	OVERCAST	15 FT. SWELL, WHITECAPS	19 - 29 KMH
25/11/87	9:00	OVERCAST	5 FT. SWELL, NO WHITECAPS	EASTERLY, 7 - 11 KMH

Figures 1, 2, and 3. Charts of the area off the southwest coast of Vancouver Island, showing where we conducted the juvenile salmon surveys. There is one chart for each of the September, October, and November, 1987 cruises. On each day of a cruise, a different symbol is used to mark where juveniles were captured. The course tracks are indicated by solid lines connecting the symbols.

LEGEND:

□ = September 25, October 9, and November 16

◯ = September 26, October 10, and November 17

△ = September 27, October 11, and November 18

◊ = September 28, October 12, and November 23

⊠ = September 29, October 13, and November 24

⊞ = November 25

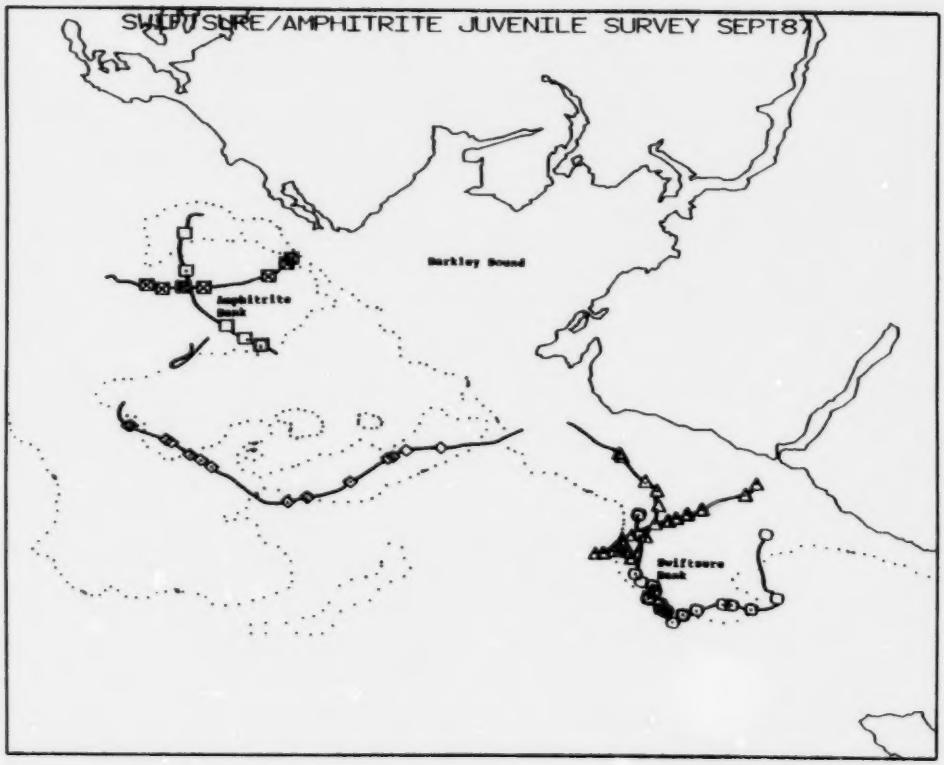
SWIFTSURE/AMPHITRITE JUVENILE SURVEY SEPT87
Barkley Sound
Amphitrite Bank
Swiftsure Bank

Fig. 1.

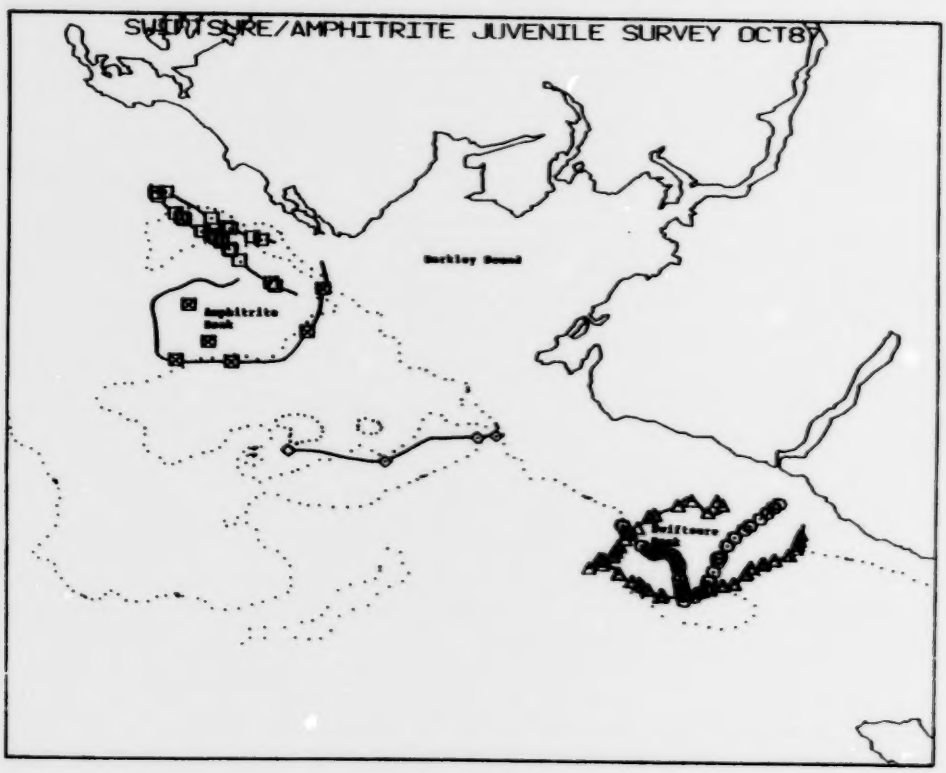
SWIFTSURE/AMPHITRITE JUVENILE SURVEY OCT8?
Barkley Sound
Amphitrite Bank
Swiftsure Bank

Fig. 2.

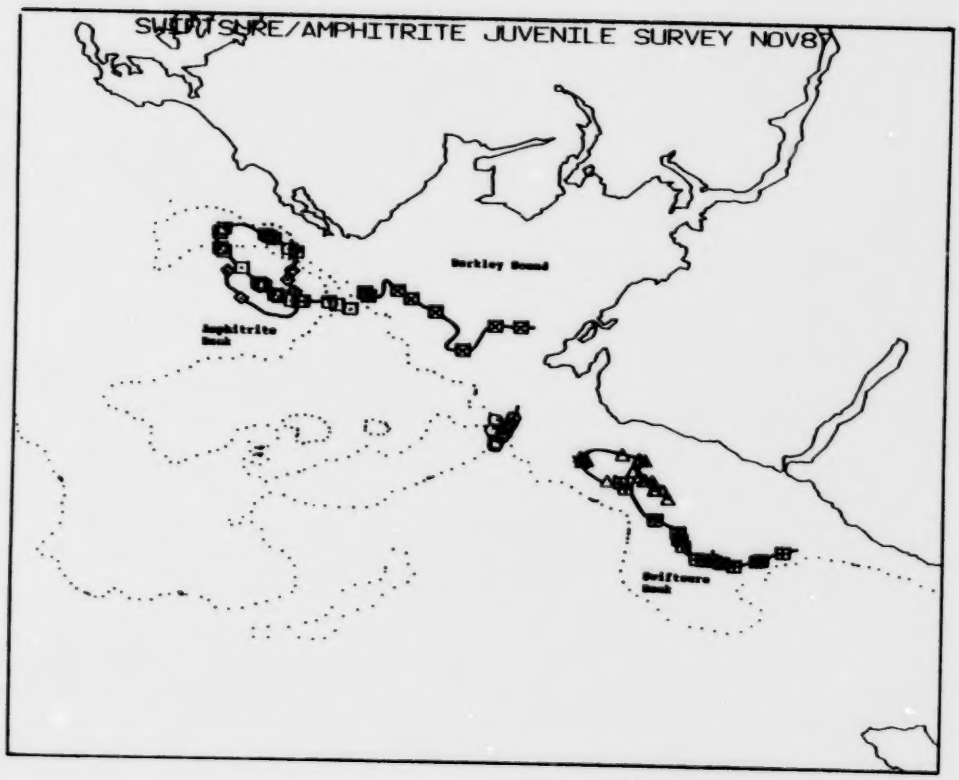
SWIFTSURE/AMPHITRITE JUVENILE SURVEY NOV8
Barkley Sound
Amphitrite Bank
Swiftsure Bank

Fig. 3.